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Reprocessing of Marine Multichannel
Seismic Reflection Profile Line 12,
Cape Hatteras, North Caroline, to Shell Mohawk Well, Canada

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ABSTRACT

U.S. Geological Survey marine multichannel seismic reflection profile Line 12 traversed 1,437 kilometers from Cape Hatteras to the Shell Mohawk well in Canada. Because of questionable velocity information and the poor quality of the original data processing done in 1978, reprocessing was requested. Five features were selected from the reprocessed line, all of which showed that with careful editing of data and careful management of certain key parameters in the software modules, the seismic image of grabens, salt domes, and deep crustal reflectors throughout the profile were enhanced, enabling a more accurate interpretation of the data.

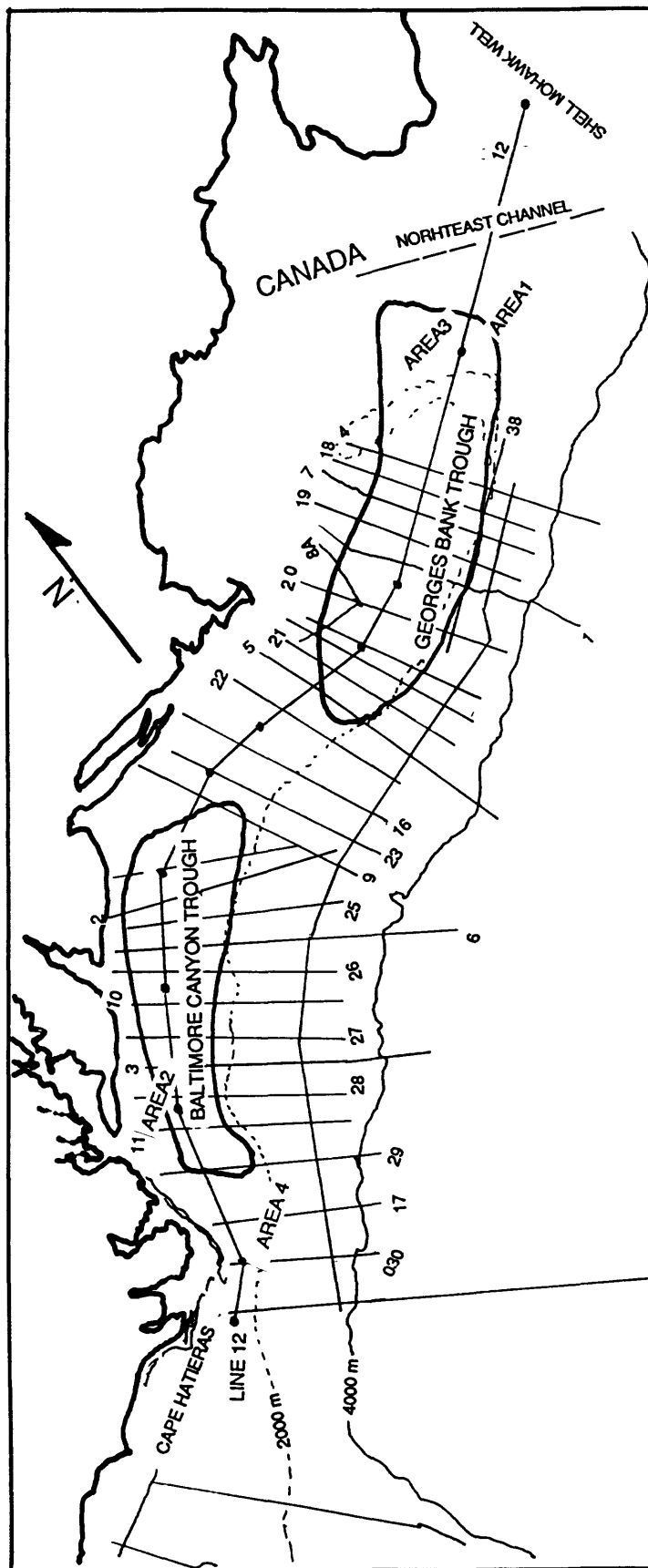
INTRODUCTION

U.S. Geological Survey marine seismic multichannel reflection profile Line 12 (fig. 1) was shot in 1975 as part of a three-year data acquisition project to give the USGS its first deep look at the arrangement of sedimentary rock layers in the mid to north Atlantic basins. Seismic Line 12 intersects 27 dip profiles and is the only regional strike line from Cape Hatteras to the Shell Mohawk well acquired in less than 100 meters of water. This particular data set was collected by Digicon Geophysical using their vessel, the Gulf Seal. The data collected were recorded by a DFS III recording system, using a 48-channel, 3,600 meter, nonlinear streamer. The seismic source was a tuned airgun array totaling 1,700 cubic inches. The geometric configuration of the streamer and the source interval was designed for 36-fold processing. Data was recorded to 10 and 7 seconds at a 2-millisecond sampling rate. Reprocessing of this data was done for the following reasons:

1. To eliminate multiples and data ringing that dominated the original profile causing unreliable picks of primary reflections.
2. To reveal and enhance primary reflections that were not seen in the original processed profile, or were highly contaminated by multiples, ringing, or random noise.
3. To provide accurate velocity information along the profile.
4. To accurately tie intersecting profiles.

OPERATIONAL PROBLEMS

The demultiplexing of marine seismic multichannel reflection data Line 12 caused several operational problems. These problems relate entirely to the original field tapes. The major problem with these field tapes is a tape skew condition. This condition occurred during the original recording of the data. During the entire survey, only one of the two tape drives used to record the data had this skew problem. Skew occurs when magnetic tapes are not mounted properly with respect to the magnetic recording heads. This causes the recording tracks to deviate



ATLANTIC CONTINENTAL MARGIN

Figure 1.-- Location map.

from their proper positions and produces crossfeed and parity errors. Due to this skew problem, more than twice the normal time was needed to complete the demultiplexing process, and even with the experienced senior computer operator, approximately 1,460 of the 29,200 shots along the line were lost.

The second major problem with the field tapes was a partial deterioration of the tapes themselves. This problem occurs when the magnetic part of the tape cracks or chips. This problem results in either a total loss of the shot if the record header ID was damaged due to deterioration, or data dropout when an area the size of a needle point is corrupted in the data itself. Deterioration is a problem that occurs with age and storage conditions of field tapes. There should be real concern with older field tapes, as we are experiencing data dropout reflected in shots lost along older lines.

REPROCESSING

Once original field tapes were properly demultiplexed, reprocessing proceeded at an efficient rate. Shot records were carefully edited to eliminate traces that contained noise, due to bad hydrophones in the streamer, or corruption in the recording system. Using parameters within the software edit-module with care and accuracy eliminated bad shot records that could have affected CDP (common depth point) records after sorting.

After edit, shot records were processed into CDP sorted records. Testing was performed to determine a mute pattern, deconvolution parameters, and filter response to eliminate and attenuate noise and to attenuate multiples and ringing. It was observed that original processed data had a very shallow mute that allowed noise in the form of refractions and direct arrivals to contaminate the stacked profile. Careful observation of CDP records allowed accurate parameters in the software mute-module to be applied, eliminating these forms of noise.

Deconvolution before stack was ignored completely in the original stacked data. This can be seen immediately (fig. 2) by the strong multiples and data ring. By testing deconvolution before stack, we found that a spiking deconvolution using an operator length of 124 milliseconds and two or three filter windows, depending on total length of data, attenuated multiples and data ring. By observation of CDP records and autocorrelations, parameters within the software deconvolution-module were made (fig. 3).

As original velocity information was not available, new velocity information was generated. This information was input, and normal moveout (NMO) was applied. A final mute was designed after NMO that eliminated upward effects of noise, data stretch, and first break noise suppression. The data was then stacked 36 fold.

Post-stack deconvolution was tested and it was determined that a 2nd zero crossing deconvolution using an operator length of 400 ms and two filter windows would collapse the wavelets into a more distinct reflection. Final post-stack filters were tested and a time variant filter was designed (see processing sequence). An automatic gain (AGC) of 500 ms was applied to the data along with a post-stack water-bottom mute and the data was displayed.

TIME IN SECONDS

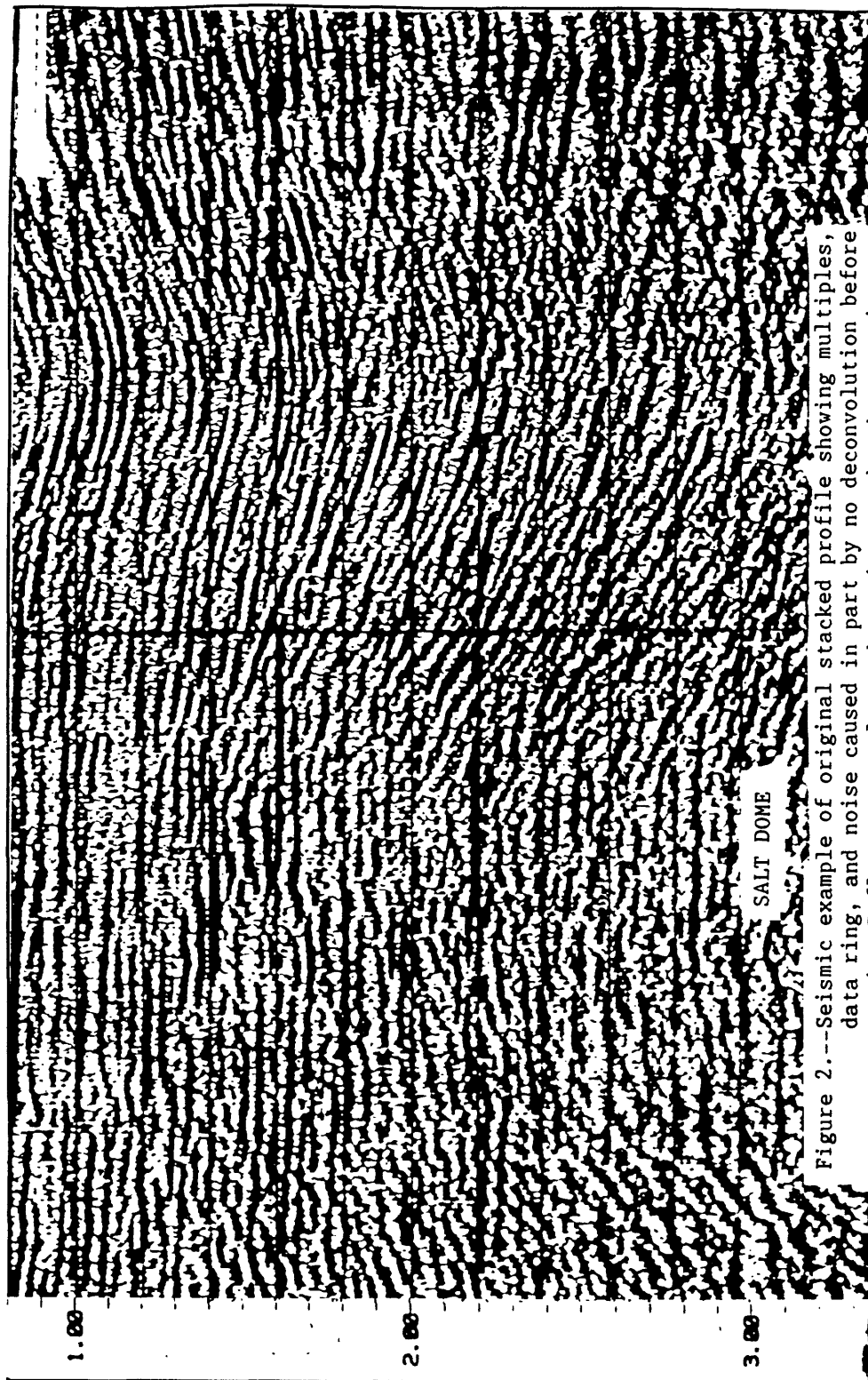


Figure 2.--Seismic example of original stacked profile showing multiples, data ring, and noise caused in part by no deconvolution before stack. Reflectors overlap and run into each other causing interpretation to be difficult. Example is from Area 1 on the location map. Direction is east to the right. Scale is 2"=2.5 kilometers.

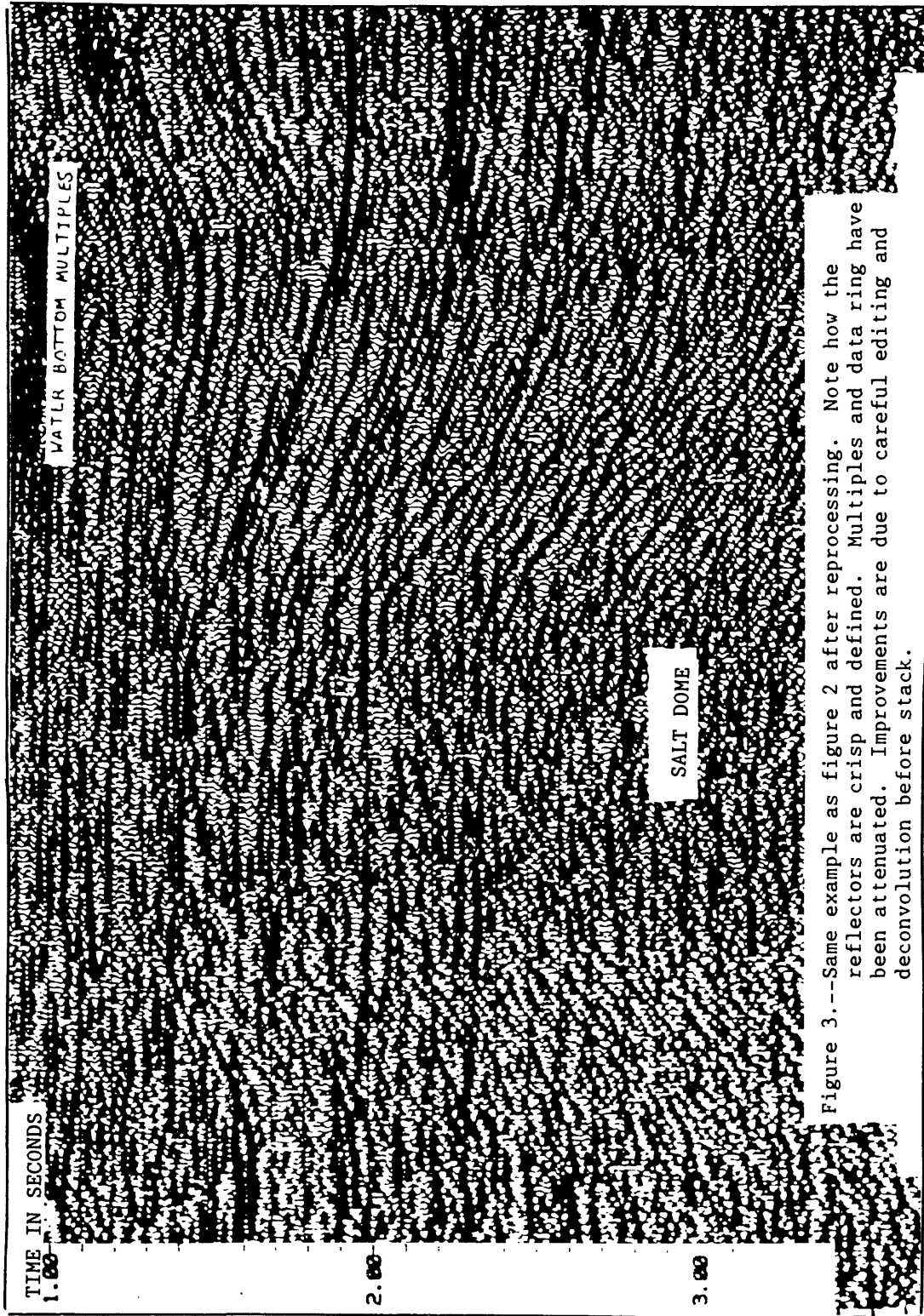


Figure 3.--Same example as figure 2 after reprocessing. Note how the reflectors are crisp and defined. Multiples and data ring have been attenuated. Improvements are due to careful editing and deconvolution before stack.

Several areas of structure at a time of 1.6 to 2.4 seconds, observed in the original section (fig. 4), were nonexistent in the reprocessing (fig. 5). These particular areas were reworked with extensive testing of geometry, deconvolution, muting, filtering, and velocities, with results confirming the accuracy of the reprocessed section. It was concluded that the original was in some way corrupted.

Table 1 describes the original processing flow. Table 2 describes the reprocessing flow.

CONCLUSION

The reprocessing of the USGS marine seismic multichannel reflection profile Line 12 demonstrates how standard processing can result in a superior product by careful editing of the data and testing of the software modules to determine parameters, prior to final summing of the data. Multiples and data ring that dominated the original summed data were attenuated in the reprocessing. Noise that corrupted the original section was almost eliminated in the reprocessing. All of the goals for reprocessing the data were achieved; figures 6-11 demonstrate the substantial improvement achieved through the reprocessing.

In addition to the reprocessing improvement, we were able to increase our data library storage capacity by 572 slots. This was accomplished by outputting demultiplexed data in a SEG-Y format at 6250 BPI and eliminating the original field data. Table 3 describes the results obtainable from this procedure.

REPROCESSING RECOMMENDATIONS

It is suggested that questionable marine multichannel seismic reflection profiles acquired by the USGS and processed by the USGS prior to 1979 be reprocessed. Using this profile as an example, the probability of superior results are high.

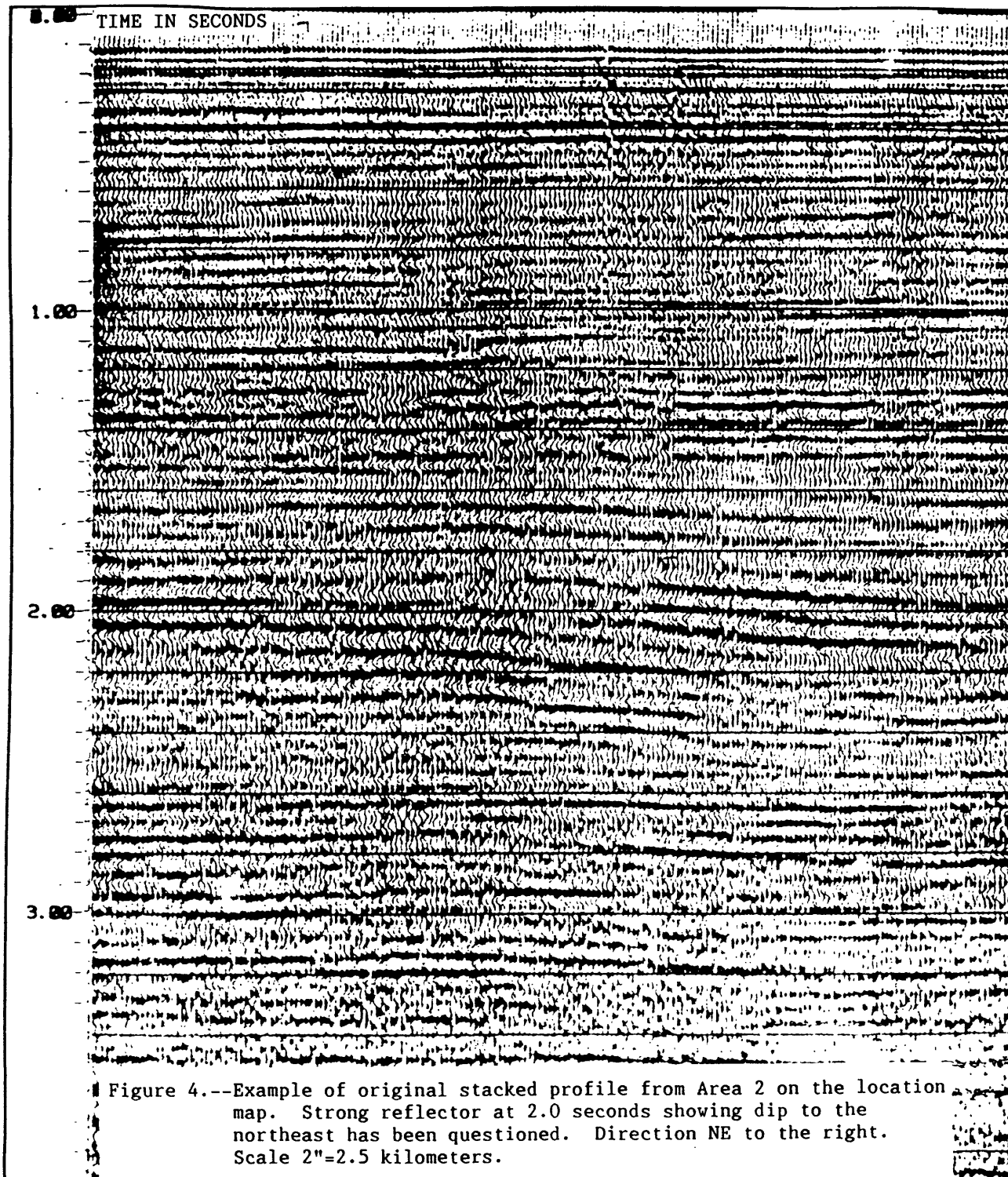
Many specific areas along profile line 12 warrant special processing. Areas of structure can be cleaned, not only attenuating but eliminating multiples. With our "discovery" system, horizons and structures can be modeled in 3 dimensions. Our group has the ability to provide some very powerful and exciting modeling displays using these older data sets.

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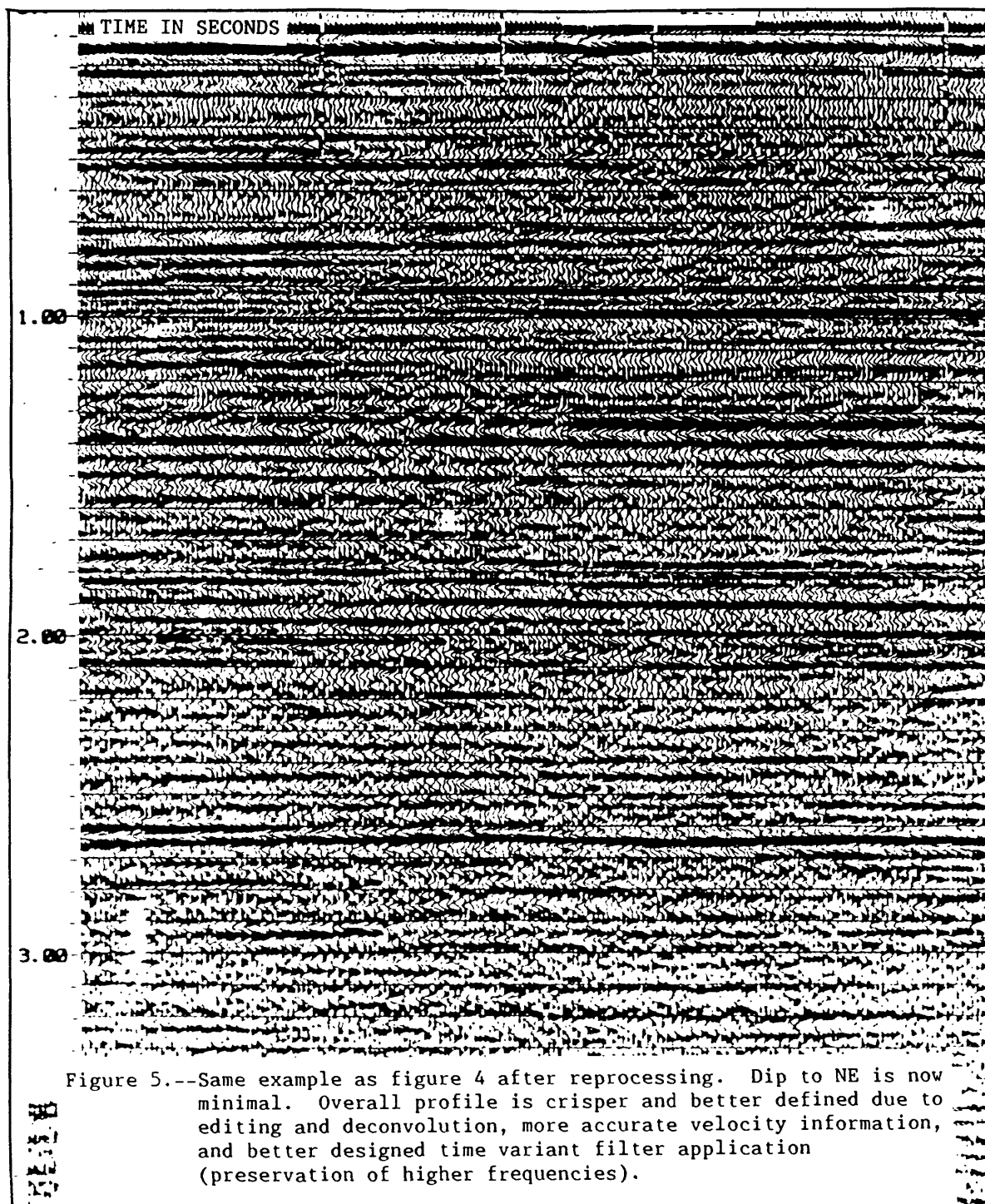


Table 1. Original processing sequence

PROCESSING PARAMETERS			
CORRECTIONS			
DATUM	Sea Level		
VE		VW	
AUTOMATIC STATICS WINDOW		TO	SEC
ADDITIONAL			
	LENGTH (MS)	WINDOW (SEC)	PREDICTION (MS)
DECONVOLUTION BEFORE STACK		-	
NONE			
DECONVOLUTION AFTER STACK	240	0.3-8.0	50
	BAND PASS	APPL. (SEC)	OVERLAP (SEC)
BAND-PASS FILTERING	12-50	0.0-1.4	.140
	8-43	1.4-3.0	.160
	4-30	3.0-8.0	
SAMPLE RATE:	4 MS		
ONE INCH:	24 TRACES		
ONE SECOND:	2.5 INCHES		
PLAYBACK GAIN:	3 DB	MEAN VALUE:	7,200

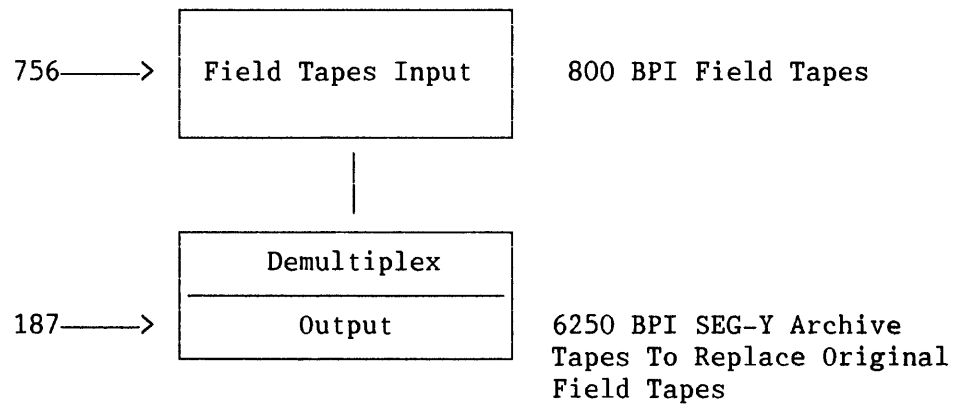
Table 2. Reprocessing sequence

PROCESSING SEQUENCE

1	DEMULPLEX	
2	RECORDING GAIN REMOVAL	
3	GEOMETRY DEFINITION	
4	TRACE EDITING	
5	RESAMPLE TO 4.0 MS	
6	COMPRESS TO 36 TRACE 100 METER RECORDS	
7	CDP SORT 36 FOLD	
8	AUTOMATIC GAIN CONTROL	
	GATE LENGTH:	1000 MS
9	VELOCITY ANALYSIS	
10	NORMAL MOVEOUT CORRECTION	
11	FIRST BREAK NOISE SUPPRESSION (MUTE)	
12	PRE-STACK DECONVOLUTION	
	TYPE:	SPIKING
	OPERATOR LENGTH:	31 POINTS
	TIME WINDOW:	0 - 2000
	TYPE:	SPIKING
	OPERATOR LENGTH:	31 POINTS
	TIME WINDOW:	3000 - 5000
	TYPE:	SPIKING
	OPERATOR LENGTH:	31 POINTS
	TIME WINDOW:	6000 - 10000
13	STACK 36 FOLD	
14	POST-STACK DECONVOLUTION	
	TYPE:	2ND ZERO CROSS.
	OPERATOR LENGTH:	100 POINTS
	TIME WINDOW:	0 - 3000
	TYPE:	2ND ZERO CROSS.
	OPERATOR LENGTH:	100 POINTS
	TIME WINDOW:	4000 - 10000
15	BANDPASS FILTER	
	TIME:	BANDPASS:
	-----	-----
	0 - 500 MS	8/12 - 40/45
	1500 - 3000 MS	8/10 - 35/40
	5000 - 10000 MS	5/8 - 28/33
16	AUTOMATIC GAIN CONTROL	
	GATE LENGTH:	500 MS
17	DISPLAY	
	SHOT POINTS ADJUSTED TO ACTUAL	
	ANTENNA POSITION	

Table 3. Library compression

Cost Efficiency



OUTPUT RATIO 1:4.1

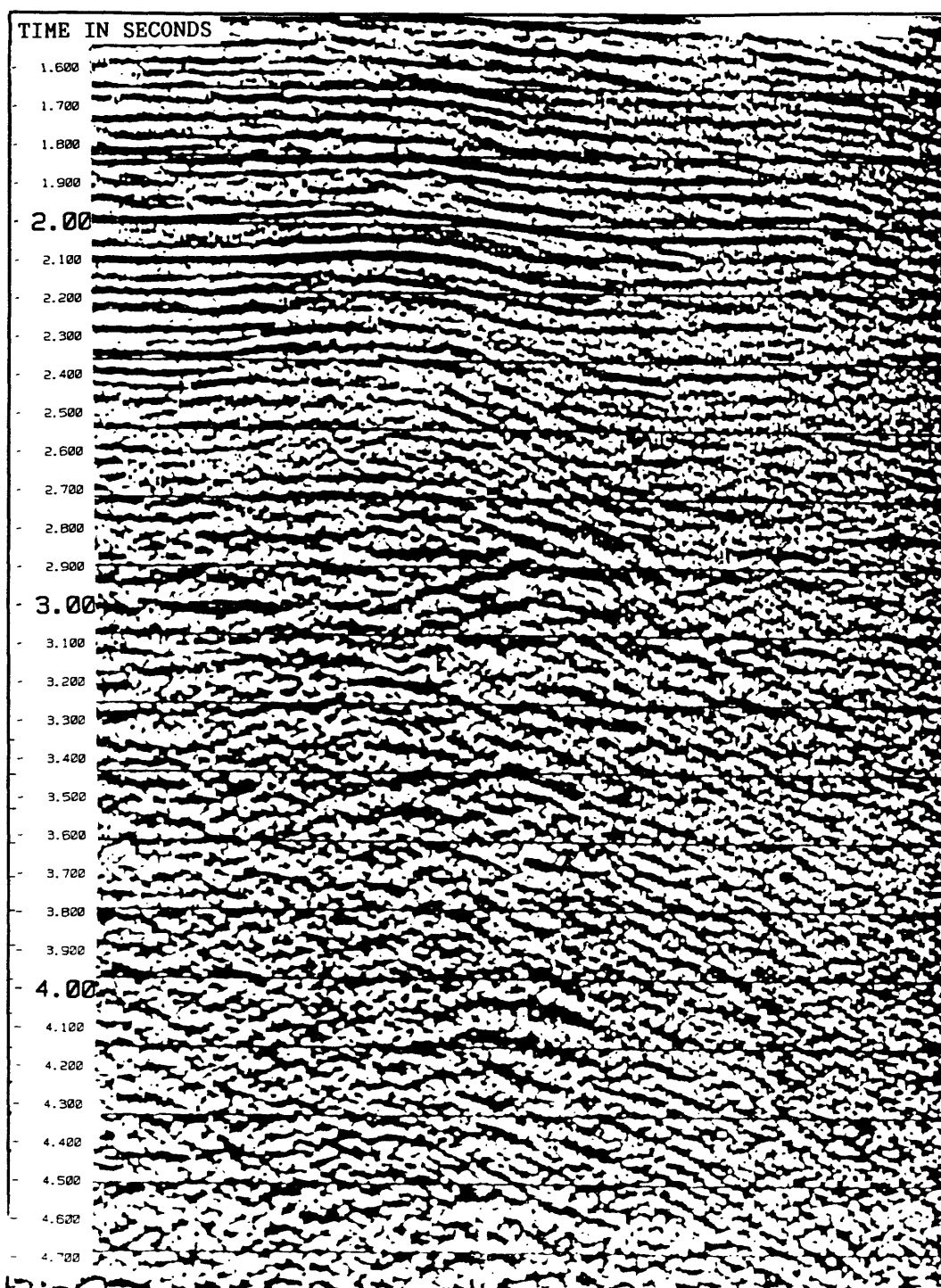


Figure 6.--Example of original stacked profile from Area 3. Clarity of reflectors is poor due to velocities, lack of deconvolution, and filtering. Compare the data at 2.4 to 3.4 seconds with figure 7. Direction is east to the right, and scale is 2"=2.5 kilometers.

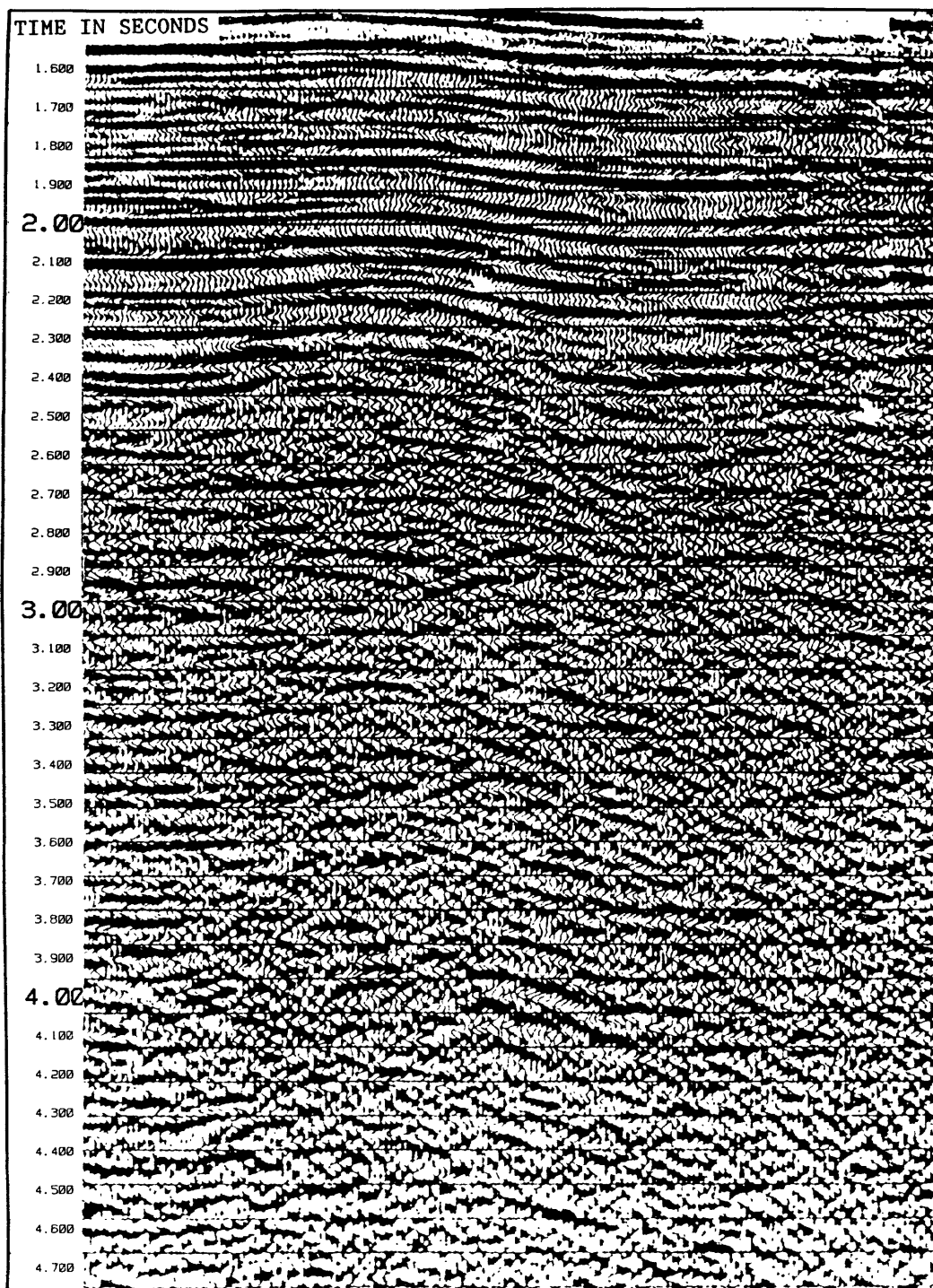
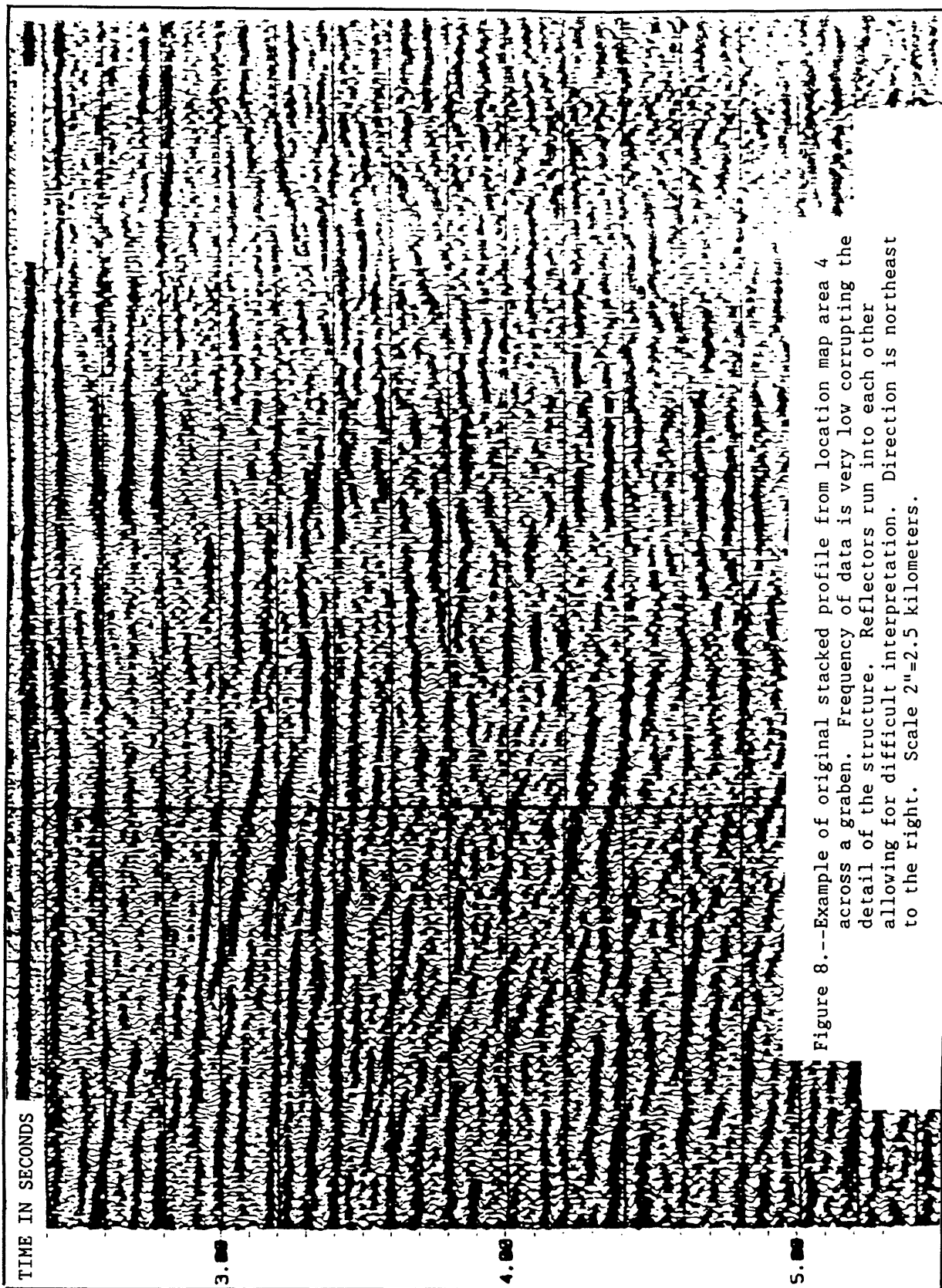


Figure 7.--Same example as figure 6 after reprocessing. More reliable interpretation of faults and structure. Reflectors stand out due to careful processing of the data.



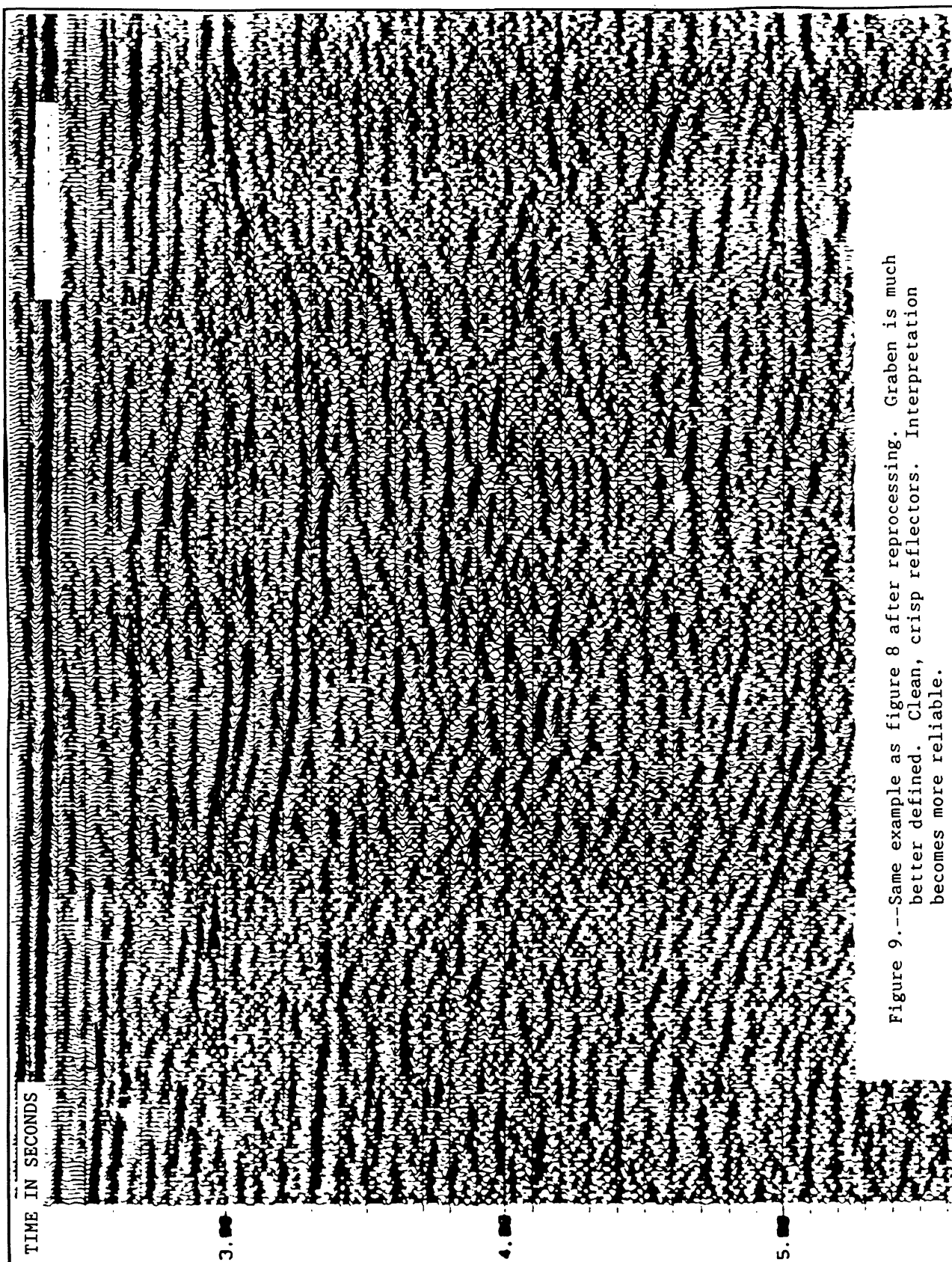


Figure 9.--Same example as figure 8 after reprocessing. Graben is much better defined. Clean, crisp reflectors. Interpretation becomes more reliable.

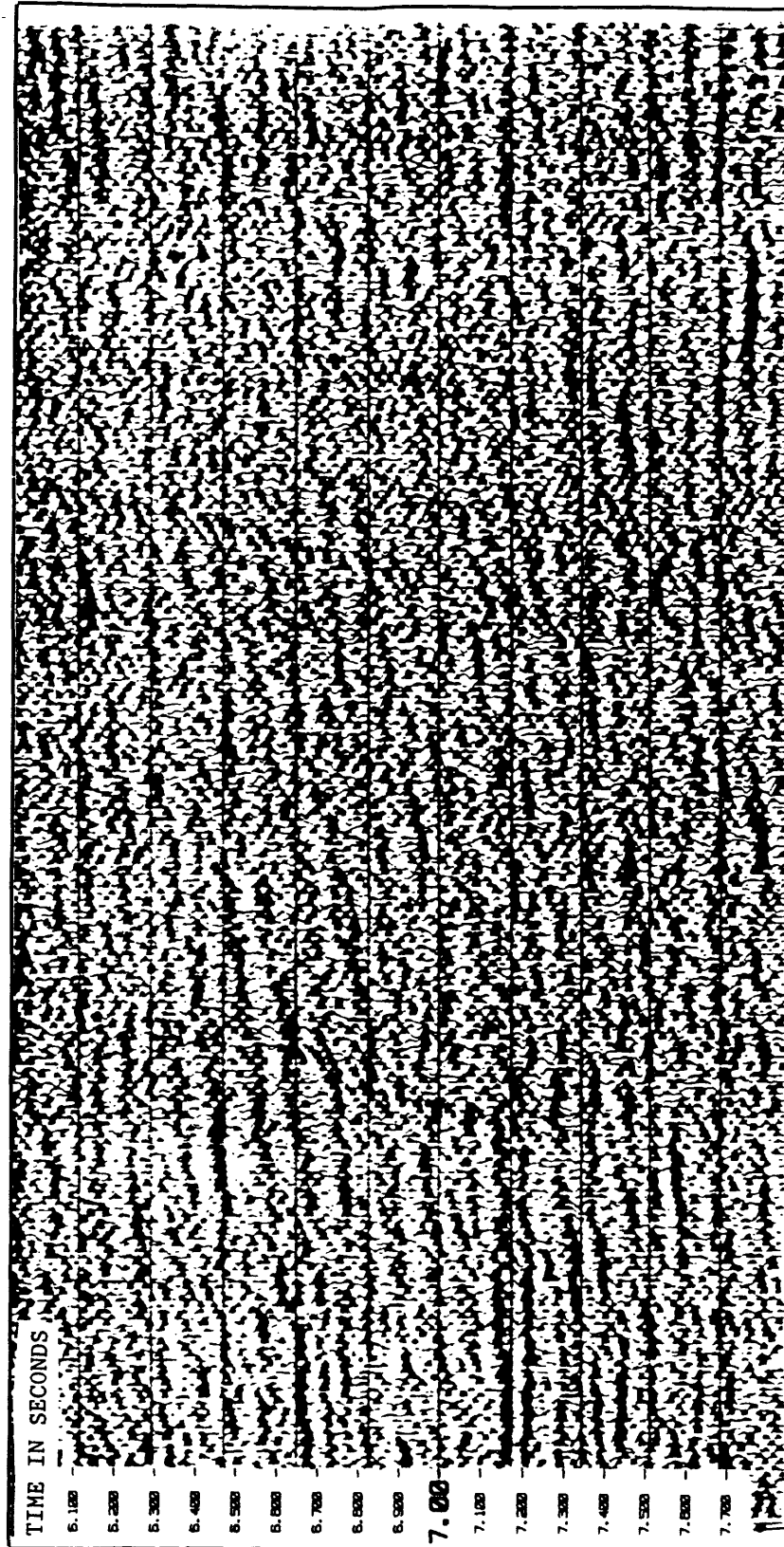


Figure 10.--Original processed stacked profile. Note original processing was to 8.0 seconds only. Poor choice of parameters caused this section to have the same overall look. Noise and velocities have corrupted this data. There was no deconvolution before stack applied. Location map Area 2. Direction is east to the right. Scale 2"=2.5 kilometers.

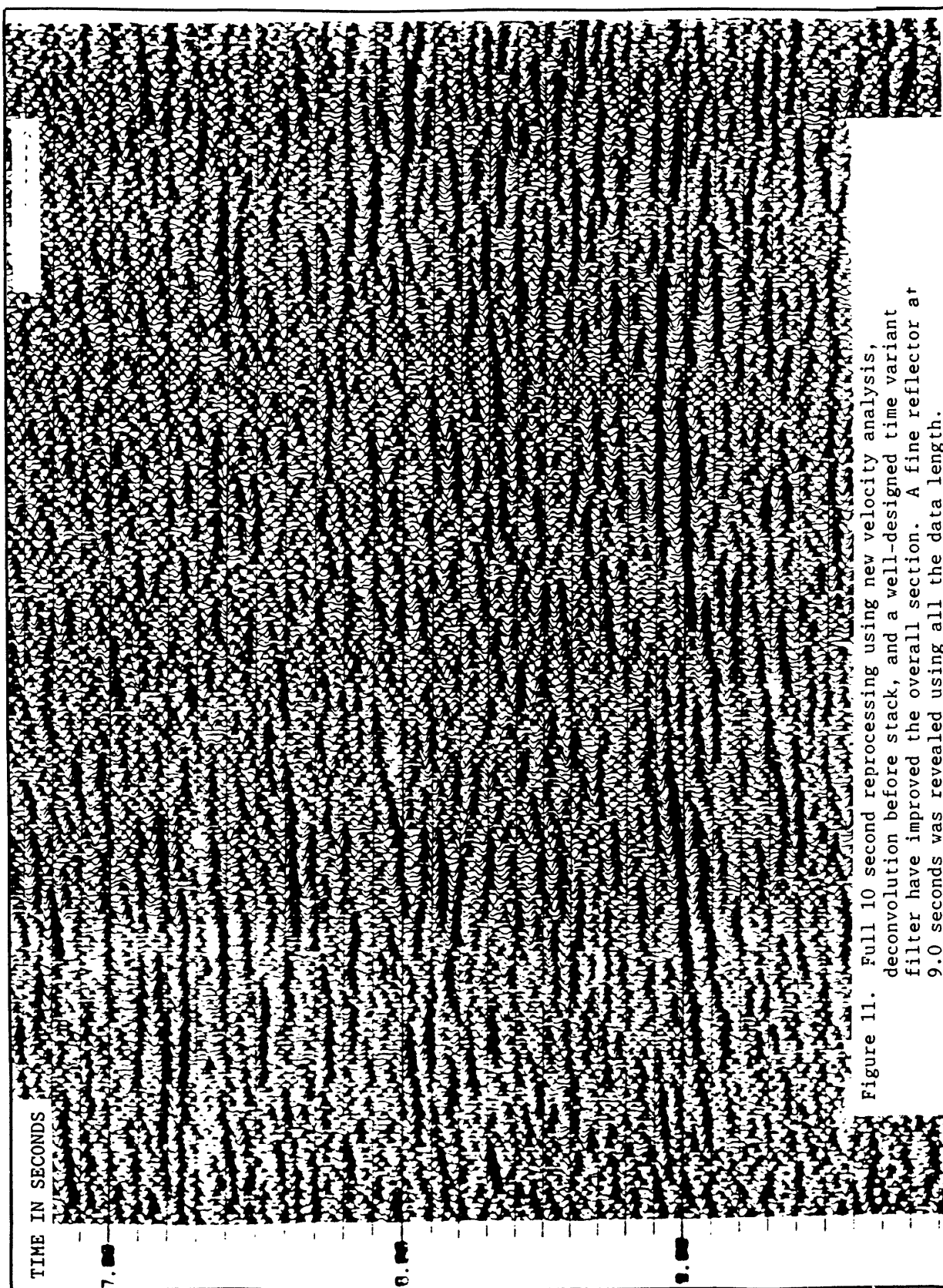


Figure 11. Full 10 second reprocessing using new velocity analysis, deconvolution before stack, and a well-designed time variant filter have improved the overall section. A fine reflector at 9.0 seconds was revealed using all the data length.